ARKIV FÖR FYSIK Band 11 nr 25

Communicated 12 September 1956 by MANNE SIEGBAHN and ERIK HULTHÉN

On the possible electric monopole transition in Se^{76}

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With 2 figures in the text

An electric monopole transition takes place without change of nuclear spin and parity. It has been known for a long time, that such a transition is allowed by current theory, but that it cannot be realized by electromagnetic radiation and that therefore the energy must be liberated through inner conversion or inner pair production both of which can carry away zero angular momentum. The first of these deexitation processes is of course the only possible one when $E_\gamma < 2\ mc^2$. Pure $E0$ transitions can be expected between levels of spin zero and equal parity which is an unusual configuration, but such transitions has nevertheless been observed. However, it has recently been pointed out by Church and Weneser [1] that also between levels of higher spin than zero $E0$ may compete favourably with other multipole orders, particularly $M1$ and $E2$, which one expects to find in such cases. The situation is explained in Fig. 1, where the probabilities of $E0$, $M1$ and $E2$ are compared [1], computed according to the Weisskopf approximation for $E_\gamma = 500$ keV. In spite of the fact that the halflives have been shown experimentally to be up to 100 times shorter than the theoretical estimate, the $E0$-mixing may still be important even at low Z, where the small relative probability of $E0$ is to a certain extent compensated by low conversion coefficients. In order to obtain an upper limit for the $E0$ percentage in an $M1$–$E2$ transition the present investigation of the conversion spectrum of As^{76} was carried out.

As^{76} decays by β-emission ($T_{\frac{1}{2}} = 26^h$) into stable Se^{76} and excites 3 levels in this nucleus (Fig. 2). The data of the strongest γ-lines are given in the following table.

Table 1.

E Mev	I_γ	Multipole order
0.5605	200	$E2$
0.643	20	$M1+E2$
1.200	21	$E2$

The intensities have been determined [2] with a lens spectrometer as well as with a scintillation spectrometer and may be regarded as well established. Spins, parities and multipole orders have been assigned on the basis of the K-conversion coefficient for the 0.56 Mev line and angular correlation measurements on the 0.56–0.64 cascade, and finally some weaker information obtained from β-branching. In the 0.64 Mev line,

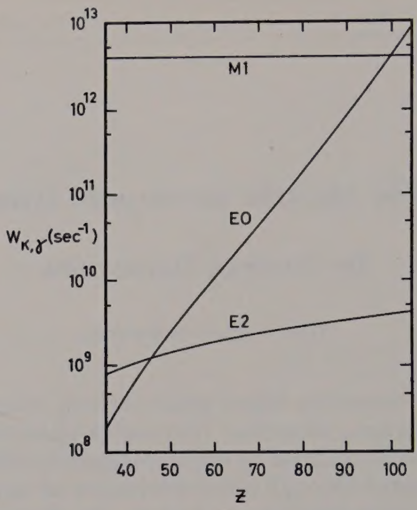

Fig. 1.

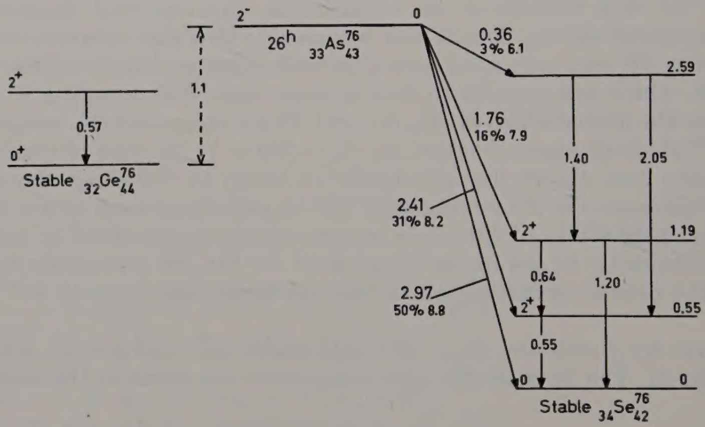

Fig. 2.

which is known from its angular correlation to be an approximately equal mixture of $M1$ and $E2$, one would thus anticipate some small fraction of $E0$. In the experiment we used a thin evaporated coating of As_2O_3 on an Al-strip of size 4×15 mm². The sample was irradiated for 2 days at about 8×10^{11} neutrons/cm² sec in the reactor of AB Atomenergi. With a double-focusing magnetic spectrometer, $\varrho = 50$ cm, the electron spectrum was investigated with an instrumental halfwidth of 0.4%. At this geometry the strongest K-conversion line was found to be 18% of the continuous β-background. An attempt to check the multipole assignment of this line by measuring the K/L ratio gave insufficient statistics because of the exceptionally high K/L ratios in this region of Z, but it could be concluded that $K/L > 8$. In view of the many evidences, theoretical as well as experimental, for a pure $E2$ transition of 0.560 Mev, we accepted the value 1.8×10^{-3} as the conversion coefficient, and since the γ-intensities were known it became possible to determine an upper limit of the conversion coefficient of the 0.64 Mev line. The limit could be set at 3×10^{-3}, and the result is that the $E0$ fraction is at most 0.2%. Taking into consideration the empirical corrections to Weisskopf's estimates of the lifetimes,[1] the result obtained supports Fig. 2.

A low-lying level above the ground state in Ge^{76} has recently been discovered from data of nuclear reactions [3]. This level is about 0.5 Mev below the ground state of As^{76} and as a consequence could be populated through the decay of the latter isotope by K-capture. The corresponding γ-line ought to appear about 6 keV above the strongest line in Se^{76}. This region was thoroughly searched by recording photoelectrons from a Uranium foil, but the result was negative, and it could be concluded that this state will exist at most in 5% of the disintegrations.

The author thanks Professor Kai Siegbahn for his kind interest in this investigation.

Uppsala, May 1956.

REFERENCES

1. Phys. Rev. *100*, 943, 1955.
2. KURBATOV, MURRAY and SAKAI, Phys. Rev. *98*, 674, 1955.
3. HEYDENBURG and TEMMER, Bull. Am. Phys. Soc. *30*, 3, 1955.
4. HEYDENBURG and TEMMER, quoted in Nuclear Level Schemes, June 1955.

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[1] It seems to be a good assumption that the E 2 transition probabilities of the 0.64 Mev and the 0.55 Mev lines are about equal. Now the first one has been shown to contain roughly 50 % M 1, which speeds up the transition by a factor of 2, and if we use coulomb excitation data [4], yielding a mean life of 10^{-11} s we arrive at $\tau = 5.10^{-12}$ s for the mixed line. On these assumptions our upper limit for the E 0 transition probability would 4.10^{8} sec^{-1}.

Tryckt den 3 december 1956

Uppsala 1956. Almqvist & Wiksells Boktryckeri AB